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PERSPECTIVES ON PRESENT AND FUTURE RELATIONSHIPS BETWEEN TRANSPORTATION AND THE ENVIRONMENT IN THE CITY OF SEOUL, REPUBLIC OF KOREA

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Transportation and Urban Life: An Introduction

The primary requirement for the mobility of people and goods in a region derives from the spatial separation of various activities which must interact in some way for their common good. People rarely live where they work, and so the need to travel between workplace and home results. Similarly, it is not often possible to extract raw materials, process, market, and consume them as finished products at a single location; the need for commodity movement is thus created. Fundamentally, then, the demand for transportation is a derived demand: people and goods must be moved about within a region for purposes related to life style and life quality. Transportation is thus a support system in a region.

In performing this function, transportation also serves as a unifying force within a region, making interaction over distance possible or more economical. In some cases, of course, transportation may be viewed as a commodity in itself when people elect to ride from place to place to enjoy the recreational aspects of the ride itself. Even in this case, however, the demand derives from a need to recreate, to view a new part of the city, to smell the fresh air in the countryside, not simply to travel.

To assess the urban transportation system in Seoul, Republic of Korea, or any other city, then, it is essential to view that system from at least two perspectives. First, one must examine the degree to which the system meets the needs for which it is built: mobility of people and commodities and accessibility of places. Second, one must consider the full spectrum of costs associated with meeting those needs: economic costs, human costs, and environmental costs.

The importance of considering the degree to which Seoul's transportation system provides transportation services may be clarified by considering the fact that the full set of system costs represents the price the residents of Seoul pay for their transportation. To determine whether or not that price is too high, one must know the benefit to be received from paying it. Furthermore, transportation can be studied in itself as an element of the urban environment of Seoul. Poor transport service will produce negative effects on the quality of life for urban residents, just as will poor air quality or high ambient noise levels. For example, one cost of not meeting the demand for transportation is congestion on the streets; in a sense, congestion is a sign of life in a city, but it clearly indicates wasted time, wasted vehicle operating costs, increased noise and air pollution, and increased traffic accidents, as well. Restricted transport services also will retard economic growth of an area, and reduce the rate of social interaction. While it is difficult to assess the true costs of unmet needs and unmade trips in an urban area, these are real costs.

To study all of the costs associated with providing urban transportation in certain ways requires the consideration of many kinds of costs. Until very recently, the primary criteria for evaluating transportation systems and proposals were economic in nature, measured in monetary terms. Unfortunately, however, it is often the case that no markets exist for some of the resources consumed to build transport facilities —or if they do, the market prices often do not reflect the true value of those resources. For example, there are often significant social costs, such as wasted time, severance of existing social interaction channels, disruption of neighborhoods, displacement of families, businesses, and institutions, and injury and death due to traffic accidents. Environmental costs of

transportation include effects on air quality, noise levels, water quality, aesthetics, and valued vistas, historical artifacts and places. Transportation system characteristics also directly influence the spatial structure of urban development through the differential provision of accessibility to various places in the region. In this way, transportation can not only positively contribute to the desired growth of the city, but it can also cause growth patterns which place undesirable pressures on environmental resources such as water, air, and open space.

These many inter-relationships between a transportation system and its urban environment can only be considered in the context of trade-offs between benefits and costs, between positives and negatives. There is no absolute in the planning and evaluation of transportation systems. Environmental resources cannot be viewed as absolutely untouchable if the city is to remain viable. At the same time, meeting a given transportation need cannot be considered to be essential. Instead, it is necessary to carefully weigh all of the benefits against all of the costs.

To understand the transportation-environment relationships in Seoul presented in the following sections, however, it is important to recognize that the foci of transportation planning in the most highly developed countries have until recently been on demand forecasting and economic cost analysis. The state-of-the-art in travel demand modeling, and the forecasting of demand shifts in response to transport system changes, is relatively well developed. The measurement of monetary costs can also be accomplished with considerable precision. Comprehensive systems evaluation, including consideration of non-monetary social and environmental impacts, is still in its infancy. Essential models to predict the effect of transportation facilities on air quality and ambient noise levels have

evolved only over the past few years, and their reliability is still very limited. Their general, regular utilization in planning is quite rare, although in the United States, the requirements of the Environmental Policy Act of 1969 are changing this situation. Much research has focused on the measurement of social impacts, but, while some progress has been made, major problems have not yet been solved. Finally, it is also clear that the interactions between transportation and land use, which have been assumed in system planning for two decades or more, are still not well understood. Thus, the specific effect of a particular urban transportation investment on growth of a city cannot be precisely estimated.

It is in the context of this limited state-of-the-art that this report attempts to assess the current and potential linkages between transportation and environment in Seoul. It begins with an analysis of the transportation system itself, followed by an identification of some significant environmental impacts of transportation in Seoul, and a consideration of the relation between transportation and urban development. The transportation planning process itself is considered next, after which the availability of appropriate professional skills is evaluated. Finally, recommendations for improved consideration of the environmental impacts of transportation in Seoul are presented.

Transportation as an Element of the Environment in Seoul

The Road Network

Considering the rapidity of its recent growth, Seoul has an extensive and relatively well-integrated urban transportation system. The backbone of this system is the road network, which carries bus, automobile, truck, animal-drawn, bicycle, and pedestrian traffic. This road network is being

developed and improved to meet current and future needs, with the primary emphasis on short-term improvements.

The connections to the hinterlands of the city consist of a traditional radial road network, the structural features of which become apparent beyond the ten-kilometer ring from the center of the city. These radial components have their highest densities in the southeast, south and southwest corridors leading out of Seoul. Development to the north is restricted both by topography and by the propinquity of the demilitarized zone. Both density and quality of roadways decline rapidly with distance from Seoul. The primary intercity connections are formed by two major tollways, the Seoul-Inchon Expressway to the southwest and the Seoul-Pusan Expressway to the southeast. Both of these facilities are high-quality, four-lane, divided, limited access roadways. Most of the other roadways are two-lane facilities, and apparently many of these are unpaved or at best gravel-surfaced. Since many of these are farm-to-market and commuter links, their current condition surely provides a restraint on economic development. The average daily traffic volumes on the two expressways in 1971 reported by the Ministry of Construction (Seoul/Pusan: 14,000; Seoul/Inchon: 12,500) suggests their importance to trade and social interaction (1). About 45% of these vehicles were trucks, a very high proportion by western standards. Thus, these high-quality exprssways play major roles in the economic viability and competitive position of Seoul.

Within the 10-kilometer ring, the road pattern becomes more grid-like in nature, subject to severe topographic restrictions provided by mountains. Major roadways serve as district boundaries, providing relatively good access around the edges of communities, and discouraging heavy through

traffic voluems in residential areas. While the density of this inner grid seems sufficiently high to meet the urban transportation needs of Seoul, topographical and operational details place heavy restrictions on through traffic movements in the central city. For example, the presence of such physical features as Mount Nam San, the Han River, and rugged hills on virtually all sides of the central area of Seoul leads to the absence of viable through routes for vehicular traffic. The common use of left-turn prohibitions in the central business district, combined with one-way streets, often make vehicular trip lengths excessively long. To these problems are added heavy central-area congestion at most hours during the day, and disruption due to subway construction under major downtown streets, all of which add up to an inflation of the vehicle-miles and vehicle-hours of travel in the central area. This results in losses of monetary and human (time) resources which probably have significant effects on the economic development and social viability of Seoul, in addition to increasing air pollution and ambient noise levels.

In an apparent effort to deal with this severe central-area congestion, a number of short, elevated and depressed highway segments have been constructed in the central portion of Seoul. There are a few "through-lane" underpasses and overpasses, which serve to carry through traffic under or over a very congested intersection, while leaving the operation of the intersection itself relatively untouched. There are also a few sections of elevated, expressway-type facilities which allow traffic to cut across railroad yards and other impassible areas, resulting in shorter trip lengths and higher average speeds. There are two collector/distributor expressway sections designed to carry traffic into and out of the central business district without interference with local street traffic.

All of these elevated facilities are located in structures in the rights-of-way of ground-level streets, thus minimizing the taking of additional land for highways. The Samil Expressway, an east/west collector-distributor on the east side of the central area, was built over the Chunge Chon sanitary canal, which was then covered to provide a surface-level local access street. All of these expressway-type facilities must be viewed primarily as solutions to short-term traffic operations (congestion) problems. They do not, as yet, form an integrated urban expressway system, the purpose of which would be to distinctly separate local from through trips. The city of Seoul has formed a traffic analysis team which in the future will attempt to formulate an overall expressway plan. The lack of an integrated planning activity to support the design of these facilities could potentially lead to planning problems in the future. Noise from elevated expressways surely has an impact on adjacent apartment developments; but low traffic volumes and separation of facilities from residents by over 100 feet reduce the seriousness of this problem. Aesthetically, elevated highways in Seoul do not meet U.S. standards, but somehow they seem to fit into the landscape of Seoul without much negative impact.

The super-block pattern of land use development complements, and is complemented by, the street pattern within the ten-kilometer ring. In this pattern, major arterial streets circumscribe superblocks, within which residential, commercial, and some industrial activities are housed. Interior streets are narrow, often winding due to steep grades, and frequently impassible to vehicular traffic. Density of development within these superblocks is very high, thus contributing to very high overall population densities in Seoul —on the order of 50,000 persons per square mile. Circumscribing arterial streets are usually wide (over 100 feet),

and have adequate capacity except in the central business district, where congestion is heavy. The arterials offer high accessibility locations for commercial activities. This is advantageous to residents of the superblock interiors, who thereby have relatively short —usually walking — trips to shops and jobs. In many areas, entrepreneurs tend to group similar commercial establishments together, so that buyers may find one block devoted to kitchen fixtures, another to auto parts, and another to office furniture. This pattern, again, keeps trip lengths short and probably increases competition to the advantage of the purchaser.

The superblock pattern also contributes favorably to the quality of the living environment within the blocks. Low levels of vehicular traffic within superblocks reduce pedestrian accident exposure, ambient noise levels, and air pollution. On the other hand, longer trips, including those to and through the central business district, are made more difficult because of the necessity to walk to public transit stops. Narrow, winding streets in these interior spaces also restrict emergency service access. This street patern, and the high density of residential development, lead to a fire-fighting strategy of containment rather than attempting to save structures which are already aflame.

Superblocks are relatively economical in the use of land for transportation purposes, with approximately 20% allocated to streets in the developed area of Seoul, compared to 27 to 30% in most large U.S. cities (2). All evidence suggests that this pattern will be maintained in central Seoul in the future. The policies for new transportation facility construction focus on the use of existing rights-of-way, rather than the acquisition of new lands. This results in economy of construction and minimizes the

displacement of homes and businesses. On the other hand, it does restrict the development of the transportation system itself, constraining levels of service (increasing travel times, travel distances, travel costs, accidents, etc.). More grid-like street patterns are proposed for new areas of development south of the Han River —the next proposed growth pole — and for the new government center on Yoido Island. It is interesting to note, however, that the new city of Kwang Ju, about 30 kilometers southeast of Seoul, is structured around a superblock pattern, with two interior ring roads carrying one-way traffic connected to a large-scale exterior grid system. Thus, the pattern of this new town, intended for a future population of 500,000, may indicate that the Koreans prefer to live in the superblock style, with high-density modules surrounded by wide streets.

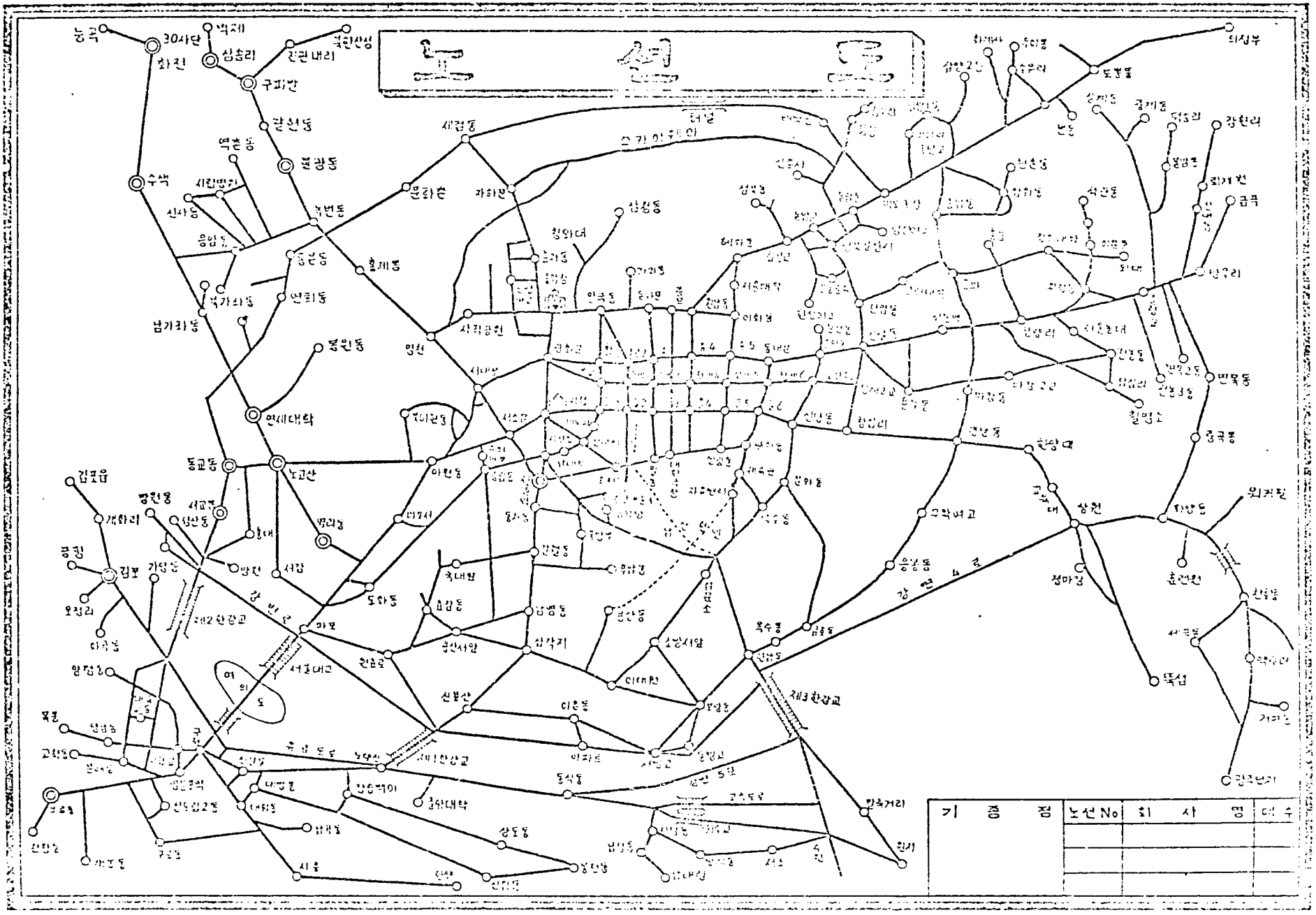
The Passenger Transportation System

The 1969 traffic origin and destination survey, carried out by the Korea Institute of Science and Technology for the City of Seoul, identified travel patterns based on a 2% sample survey of households (3). It was found that the approximately 5.5 million people made about 6.7 million trips on an average day. More specifically, about half of the population made no trips, and about half made two trips. Thus, the trip-making rate was about one person-trip per person. This is approximately 50% of the typical U.S. trip-making rate. In these figures, a trip to work and then back to home is counted as two person-trips.

The bus transportation system carries approximately 70% of the average daily person trips —that is, about 4.7 million trips per day. It carries 76% of the home-work trips. These tasks are accomplished through the use of a fleet of about 4300 buses, 4100 of which are privately owned

and operated (4). The remainder of the intra-city buses are operated by the City of Seoul, primarily over routes which would not be profitable for private operators, but where service is socially or economically essential. It is said that there are about 300 private bus companies in Seoul; while the city government has encouraged consolidation of services, the private owners seem to have no interest in doing so, which suggests that bus operations are highly profitable in Seoul. This fragmentation of ownership very likely increases the cost of service to the trip-maker.

The bus route network is quite extensive, as shown by the map on page 11. Relatively good coverage is provided to all areas of the city, although the focus of the routes is clearly in the central business district. By general policy, bus stops are spaced about one kilometer apart, and buses are operated on 5- to 10-minute headways throughout the day. It is apparent, however, that these service characteristics vary widely over the city. Buses operate on a flat-fare system —a constant fare for any distance traveled —but transfers are not permitted: that is, if a trip requires the use of two separate bus routes, two full fares must be paid. The standard fare is 20 won (about 5.25¢), with special, lower fares for school children. The buses on which this fare is charged have only limited seating capacity on bench-type seats running longitudinally inside the buses. Aisles are wide, and during peak periods the majority of riders can expect to stand. "Premium" service is also offered on some routes, at a charge of 30 won (about 8¢) per ride. In these buses, seats are arranged transversely on either side of a narrow aisle, and most riders can expect to be seated. Thus, a 10-won premium is charged for increased comfort. Assuming that a typical worker goes to his job about 300 days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per year (the work week is often 6 days long), and spends 40 won for the round trip, the annual cost of travel to work would be 12,000 won or $32. Estimates of average annual per capita income in Seoul offered by staff members of KIST were approximately $215. Thus, the worker might spend about 15% of his income on home/work transportation. Other trips, for shopping, recreation, and personal business would increase this fraction significantly. Even with the low bus fares, then, the average Seoul resident seems to commit a significant proportion of his income to travel.

While buses carry most of the trips in Seoul, they also make major contributions to congestion, noise, and air pollution. Because of their relatively large size —similar to U.S. school buses —and poor performance characteristics, buses reduce travel speeds of street traffic, particularly on peak-volume central area streets, some of which carry over 300 buses per hour.

Much of the inter-city travel in Korea is also by bus: 10 to 20 percent of the traffic volume on intercity toll roads is composed of buses. The new city of Kwang Ju is connected to Seoul by intracity bus routes.

There are more than 12,000 taxis in the city of Seoul, a very large number by western standards. Essentially all of these are tiny vehicles of Japanese design, which can comfortably carry two persons. Taxis crowd the central business streets at practically all non-curfew hours, and are easy to hail in that part of the city. Their presence is less noticeable outside the 5-kilometer ring, yet several officials reported that they regularly traveled to work from residential areas by taxis, which were easy for them to find. Access to taxis is simplified by the designation of taxi stops throughout Seoul. These are usually small, covered waiting

shelters, colorfully marked and frequently spaced. Taxi drivers are required to pick up and discharge passengers only at these stops, a system which adds an element of order to street traffic patterns, since the stops themselves can be located according to good traffic engineering standards. A high level of service for the user is still maintained, but taxis do not stop at or near main intersections, or at other similar locations likely to cause traffic disruptions or high accident risks. Taxis may pick up and discharge passengers at establishments, such as hotels, which have off-street driveways, but the driver prefers the taxi stops, where his next customers are invariably queued up for a ride. Taxis are essentially ubiquitous in the central area, and fares are relatively cheap (90 won for the first 500 meters —about 24¢) by western standards. While many residents of Seoul surely cannot afford this means of transportation, a significant proportion obviously can. The average taxi makes 55 trips per day (5). In a city where a private automobile, including taxes and duties, may cost as much as $6000, the taxi offers a significant alternative. It provides convenient and rapid transportation at a much lower cost than would a private car, except for those people who must make very large numbers of trips each day. Seoul's 12,000 taxis, then, seem to fill the need for personalized transportation which in a wealthier country would be met by private automobiles. The taxi offers important advantages to the city and its residents. Since taxis are cruising most of the time, the need for municipal parking lots —currently unmet —is much reduced. Also, because they are highly experienced, it is likely that taxi drivers have lower accident rates than non-professional drivers. On the other hand, because taxis cruise all day, they increase the pollutant load on the atmosphere and add to traffic congestion. On balance, however, the ubiquity of the

taxi in Seoul is to the social and economic benefit of the population.

There are about 26,000 private automobiles registered in Seoul; this represents about 50% of the autos in Korea. In other words, there are about 5 private cars per thousand population; this is an exceedingly low rate of auto ownership by western standards (typical U.S. urban rates are over 500/thousand persons). The primary reason for this is the very high cost of automobiles combined with the low per capita income. It is the rare resident of Seoul who has access to a private car or one owned by his employer. The automobile is not yet culturally integrated into Korean society, and this is mirrored in typical driver-training courses offered by private schools. Students spend 4 hours per day, five days per week, for four months learning not only to drive, but also to understand and to maintain an automobile. A "crash" course is available at 2 hours per day for two months.

The automobile is obviously viewed as a status symbol in Korea. Anyone who can afford a car seems to be able to afford the cost of a man to drive it. Private and company cars waiting for their users to complete their business typically wait with the engine running, even for long periods of time. This adds to the pollution load, but again, auto owners can afford it. Growth of the economy and these social pressures are likely to increase quto ownership rates in Seoul, and serious consequences may result. Congestion is already severe, and accident rates are high, and these conditions may be expected to worsen. There is essentially no organized central-area parking system, and great pressures to convert land to parking lots are likely to result from large shifts toward private car usage.

Estimates of the importance of pedestrian travel in Seoul vary with the source of the data. The 1969 origin-destination study reports that about 29% of the person trips in Seoul are made on foot (6). About 15% of the work trips are made by walking, as are 42% of the shopping trips. In part, this high reliance on pedestrian travel is due to low per capita incomes and low auto availability. It is likely, however, that to a significant degree this is due to the arrangement of land uses. While no studies which analysed these relationships were discovered, it is probable that the use of the superblock pattern makes it very easy for residents to walk to the nearest arterial street to do their shopping. The same short walk linkages probably exist for work trip travel. The 1969 study reports that the average walk trip time is about 19 minutes for all trip purposes. This is quite long by any standards, and it probably represents a distance of about 1.5 miles at the typical, fast Korean walking pace. Because of the extreme circuity of the Seoul street system, however, this may reflect an airline distance of about a mile. Because of the likely effect of the superblock land use pattern on encouraging walking trips, it will be important in planning transportation and land use systems for the future to consider the value of preserving the superblock arrangement. In a sense, there is a critical trade-off relationship which exists here between encouraging walking trips and improving the quality of vehicular traffic flows.

Great pains have been taken to provide safe facilities for pedestrian movements in the city of Seoul, as well as in other places in Korea. Pedestrian overpasses or underpasses have been provided at almost every major intersection in the central business district. Overpasses are also common in the outlying areas of Seoul, and they have been built at frequent

intervals across the inter-city toll roads. On the latter facilities, access ramps to the overpasses have gentle slopes to make it possible for farmers to move animals across the roadways in safety. Within the central area of Seoul, underpasses are well lighted and very clean; some have shopping arcades within them. Yet on many central area streets within superblocks, no pedestrian-vehicular separation exists, and narrow streets are shared by all types of trip makers.

Two needs precipitate the common use of these special pedestrian crossings. First, many downtown streets are very wide —some exceed 200 feet from curb to curb. Allowing grade-level pedestrian crossing would greatly add to traffic congestion and accident risks. Perhaps the more important factor is quite subtle: the residents of Seoul are not accustomed to the automobile and its inherent dangers. People seem unaware of the threat to life and limb associated with violent interactions with motor vehicles. It is not uncommon to see pedestrians step into a street without even a glance in the direction of oncoming traffic. It is estimated that almost 98% of the traffic deaths in Seoul occur in pedestrian-vehicular accidents (7). Therefore, where the potential for conflict is high, special facilities are constructed to minimize the danger. In addition to over- and underpasses, guard rails and chains are often installed on the edges of sidewalks to keep pedestrians out of the streets and to channel them into the special crossing facilities. Observance of regulations requiring the use of the facilities is high. A pedestrian involved in an accident at a place where he failed to use an available over- or underpass may be charged by the police as a traffic violator.

While these special pedestrian safety features surely improve the lot of the walker, the dangers are still high. The automobile driver obviously

has a low regard for pedestrians. On narrow, winding streets within superblocks, where no special walkways are marked, and in places where pedestrians frequently walk in the street, drivers seem totally unwilling to yield the right-of-way to them. In such situations, the primary traffic control device —or weapon —is the automobile horn: the driver leans on the horn and proceeds, expecting all walkers to open the path before him. Drivers were observed blowing their horns out of habit, even where no one was in front of them. This leads to perhaps the most noticeable environmental impact of transportation in central Seoul, the intense cacophony on the automobile horn.

It is interesting to speculate that many walking trips in the central business district of Seoul may, inthe future, be substituted with telephone calls when availability of the telephone becomes more common. It is not possible to estimate the rate of substitution at this time because essentially no research has been done in this area. Since the potential substitutability of communications for transportation may be a source of congestion relief in many large cities around the world, it would be of considerable value to institute research on this phenomenon in Seoul.

The Commodity Transportation System

No organized statistics were found describing commodity transportation in Seoul. It was reported that, while the need for research was great, no resources had been made available to study freight movement problems. This is similar to the situation in more developed countries until recent years. About 21,000 trucks are registered in the Seoul area. Most of these are very small —perhaps having carrying capacities of 1.5 to 2.5 tons. Many of these are three-wheeled vehicles. This relatively small number of trucks does not seem to contribute much to street traffic

congestion. It is likely that trucks are primarily used to bring goods to a relatively small number of distribution centers, from which human-powered modes are used to complete trips into the central areas. Trucks seem more prevalent beyond the 5-kilometer ring and, indeed, there are many central-area streets from which trucks are excluded. This is probably due to the narrowness of those streets, and the prohibition does contribute to an improvement in both the visual environment and traffic flow. Some officials reported that trucks were used for central-area deliveries with special permission during the curfew hours, a concept which has been tried without success in England and the United States.

The most obvious methods for goods movement in downtown Seoul are the bicycle, the hand-cart, and the A-frame. Bicycles were observed carrying as many as six cases of beer, eight corrugated boxes approximately 3x2x2 feet in size, or as many as 3 steel compressed-gas cylinders. The latter may weigh from 200 to 300 pounds. Bicycles seemed to provide a very efficient way to move smaller loads through congested city streets. Often these are ridden on the sidewalks to avoid vehicular traffic delays. Through the use of bicycles, commercial activities in even the most remote part of superblock interiors could be reached. Pedestrian-bicycle conflicts were observed, but none ever seemed to result in collisions. Bicycles are equipped with loud, continuous-ring bells which seem to provide pedestrians with adequate warning. Generally, bicycles were the most commonly observed freight transportation mode in the central area.

Hand-carts are also common in central Seoul; their primary use is in collecting waste materials for re-cycling. Their slow speed makes them easier to avoid than a bicycle, but it also adds to street congestion. Typically, the smallest streets are off-limits to trucks, and the largest

to bicycles and hand-drawn vehicles. The use of wooden A-frames on shoulder straps was also common. Again, such transport modes make it possible to move goods in and out of confined areas without the dangers and environmental offenses associated with motor vehicles. The use of all of the human-powered modes can be attributed to the high cost of capital equipment and the low wage rates. One truck could probably replace several bicycle riders, but the more labor-intensive approach is currently cheaper in Seoul. Also, the heavy use of labor for freight movement tends to keep unemployment rates down. Finally, there is, once again, a trade-off between the use of human-powered freight transport modes and land use patterns. The superblocks, each containing a broad mixture of land uses, results in short trip lengths, making non-motorized transport feasible.

Animal-drawn vehicles are prohibited in the central area of Seoul, although they are sometimes observed beyond the 5-kilometer ring. These pose both sanitary and aesthetic threats to the urban environment, but their use is sufficiently rare to minimize this problem.

Land Use Patterns and Trends

The currently developed portions of the city of Seoul largely reflect the topographic constraints imposed by mountains. North of the Han River, where the majority of current development is located, residential areas extend from the central business district in the following general directions: west, southwest, and east, with some development beyond the five-kilometer ring to the northwest. South of the Han, dense development exists to the west-southwest and the east. The major developing industrial corridor lies along the roads to Inchon, to the southwest. New development is occurring along the periphery of the central city, from

the 5- to the 10-kilometer rings, and in essentially all corridors except the north. Relatively large apartment developments can be seen under construction to the northeast, southeast, southwest, and northwest. The major planned thrust of new development, however, is to the south of the Han River. This includes the area on the south bank of the Han south-southeast of the central area, which, when fully developed, will represent a major increase in the developed area of Seoul. Yoido Island, site of the new government center in the Han River southwest of the downtown, will include residential as well as office space; several high-rise apartment buildings have already been completed at this location, and complementary residential facilities are planned or under construction both north and south of the Han near Yoido. It is said that two factors motivate the development of Seoul to the south: there is available, developable land in that sector, and its separation from the demilitarized zone makes it easier to defend. This development trend will, of course, place new pressures on the urban transportation system of Seoul. For example, if the central business district continues to be a major work-trip attractor (currently 70% of all vehicular trips have origins or destinations in the central area), then significant capacity increases will need to be provided in the corridors to the south. Otherwise, efforts would have to be made to provide the developing portions of Seoul with an ability to be economically self-sufficient. Given the current trend toward establishing the central business district as the focal point of the region, meeting the needs of commuting traffic from new developments will be important. Currently only 2 or 3 percent of the population of Seoul lives in the central area; the trend has been to zone the downtown for commercial and governmen-

tal functions and to encourage residential migration to outlying areas. Zoning and building codes probably have a less significant effect than downtown land prices, which in some parts of the CBD have increased 100% from 1965 to 1968 (8). In the latter year the highest land values in the CBD were more than 10 times greater than prices as close as 3 kilometers from the center of the city. Land values reflect the characteristics of the market in Seoul, and thus may be interpreted as an indication of general economic trends arising out of a large number of factors. Generally, the rapidly increasing strength of the CBD as a focus for Seoul is quite evident. This is likely to result in generally increasing the demand for transportation, as measured in person-vehicular trips and particular in vehicle-miles of travel, which in turn will emphasize the need for additional radial transport capacity, and its associated impacts. For example, the greatest needs for transportation corridors will probably occur in the most densely developed and most expensive land. Concentration of vehicles and people in the central area will contribute to increased air and noise pollution concentrations and increased accident risk exposure.

It is not clear that significant options to this centrally focused development pattern have been carefully considered. In a sense, the city of Seoul can choose, or at least could have chosen, to follow an alternative development trajectory with a different set of associated social, economic and environmental impacts. It is not possible to argue at this point that decentralized development would, indeed, produce a more favorable future environment for Seoul. The promotion of residential areas to the south, including the policies that brought about the new city of Kwang Ju, indicate partial decentralization. Yet current evidence suggests that the relative

strength of the central business district is increasing in line with public policy, and this will surely require the commitment of more resources to the transport sector.

Current Overall Travel Patterns

Simple, aggregate descriptions of overall travel patterns in any major city are difficult to arrive at. Perhaps the most striking feature of the origin-to-destination trip linkages discovered in the 1969 survey is the strong focus of vehicular trip-making patterns on the central business district. This suggests both the over-riding importance of the home-work-home trip linkages and the fact that the central area is the major trip attractor in Seoul. The most intense residential-trip-generation areas are to the east, northeast, northwest, and southwest of the central business district. The northwest corridor is somewhat less important than the others in that many of the residences in that sector are sufficiently close to downtown employment to allow walking trips, or at least very short bus trips. As a result, the major flows in and out of the central business district are in the corridor running east from the CBD along the Samil Expressway, in a north/south corridor through the downtown along Sejong Ro, and in the southwest corridor. This represents an extremely heavy concentration of person- and vehicle-trips during the morning and evening peak periods; in fact, these corridors are running congested even at mid-day, in part due to capacity restrictions which result from subway construction disruption. Sejong Ro is carrying over 10,000 vehicles per hour in the morning peak period (9). While this and other main arterials in the downtown are quite wide, providing as many as 8 to 10 lanes of capacity in both directions, very significant bottlenecks occur at the intersections. Added delay due

to left-turning vehicles has been eliminated at many intersections through the use of turn prohibitions, at the price of greatly increasing the circuity of trip routing. Some trips were observed to require twice as much distance, and three times as much time, in one direction compared to the other, strictly because of turn prohibitions. Thus, while flows through the intersections are improved, additional vehicle-miles of travel are required, and much time is lost. There are important opportunities for traffic operations improvements in the downtown area, and the city of Seoul has placed higher priority on this effort than on overall expressway system planning.

There is relatively little inter-sector travel in Seoul beyond the 5-kilometer ring. That is, most of the trips are moving in and out of the central area, rather than between outlying areas. In part, this is due to the current land-use patterns, which place most of the residential areas in outlying radial corridors, and the bulk of the jobs in the central city. In addition, severe topographical constraints provided by mountains make the provision of high quality, surface-level circumferential routes most difficult. These restrictions probably require a considerably amount of radial travel to be made even for a purely circumferential trip. Again, the consequences of the necessary oblique or radial travel pattern is concentration of traffic in the central part of the city.

Future Transportation Plans and Needs

Very general proposals exist for the construction of a series of circumferential or ring roads, and these might provide some relief from the negative impacts of the current transportation network. However, a number of factors mitigate against the development of these new roadways. First,

the primacy of the central business district will argue for the commitment of resources to projects which most directly serve this area —new and better radial service. Second, the mountainous terrain surrounding and within the city of Seoul will make the construction of ring roads —designed to avoid the constraints of these topographic barriers —very costly. Third, since most of the travel in Seoul is, and will continue in the next decade or two, by public transit, service via ring roads may not be provided because current radial routes may be perceived as being more profitable. In other words, bus operators, facing relatively inelastic demand, may choose to select more direct routings, even if the travel times are longer. Finally, planning and location of circumferential facilities should realistically take place in the context of a much larger-scale comprehensive urban planning effort, including detailed analytic studies and evaluation, all of which is still in an embryonic state in Seoul.

Also proposed and clearly needed is improved integration of intercity radial roadways, which penetrate Seoul from the hinterlands, and the central area street network. Additional hinterland radials can be found on the planning maps, but there is a significant need to determine what to do with the traffic once it enters the city. As mentioned, through travel is made most difficult because of the congestion and circuity of central city streets. Ring roads would be helpful in alleviating some of these problems. Generally, there is a need for a complete expressway plan for the city of Seoul, covering existing and proposed penetration radials (such as the Samil Expressway), Han River crossings with sufficient capacity to meet commutation needs, and circumferential routes. Of course, it is unrealistic to suggest that any or all of these facilities are needed to serve Seoul in future years. A considerable amount of analysis must go into the

preparation of such recommendations. That study should begin at an early date.

It is important to recognize that such plans and proposals are often viewed as attacks on the social and physical environment in developed countries. Careful planning to meet the transportation needs of Seoul, both through the development of new facilities and through the direction of land use arrangement shifts, however, could make a very important contribution to preserving and enhancing the current environment. Solutions derived in times of crisis, like most short-term planning, could produce a net urban impact which is unfavorable.

One of many encouraging developments in transportation for Seoul is the subway system, portions of which are already under construction. The proposed system would ultimately consist of five distinct rapid transit lines totalling about 75 miles in length (10). The system is to be in tunnels radiating outward from the central business district to a distance of about the 10-kilometer ring. From that point, lines will run at grade. The route now under construction begins on the east side of the city, at the Korean National Railways station, travels west through the CBD, and then turns south under Sejong Ro, terminating at the central KNR station. Track, design geometrics, and rolling stock will be completely compatible with KNR equipment when the line opens in 1974, so that commuters from the hinterlands of Seoul will find it possible to travel to the CBD without changing trains. To provide this uniquely attractive service, connecting KNR routes in the Seoul area will be converted to electrically powered locomotives rather than the current diesel power. This coincides with a national plan to electrify the railroads, which is just getting underway.

As stated, all five proposed lines will pass through the central business district, and from there will radiate to the northwest, northeast, east, east-southwest, southeast, south, southwest, and west, providing extensive coverage of the entire metropolitan area. This system will obviously strengthen the relative position of the CBD as the economic, cultural, and social focal point of Seoul To the extent that travelers will be able to complete all or most of their trips on the rapid transit itself, however, the environmental consequences of this system should not be detrimental to Seoul. Direct connections are planned from the CBD to all of the major developing areas near Seoul, including those south of the Han River and Yoido Island. Much of the construction will take place after 1977.

Rolling stock for the subway is being purchased in Japan; equipment will essentially be off-the-shelf technology. While such relatively sophisticated features as automatic train operation and air conditioning are planned, the basic technology is simple and well-matched to the Korean ability to operate and maintain it. A special division of the city government has been established to plan; design, and construct the subway, and it seems to be operating at a high level of efficiency. As in the case of the Seoul Expressways, virtually no new right-of-way acquisition is required for the subway, since it is being built under existing city streets, using primarily cut-and-cover methods of construction. This approach, of course, requires that surface streets be severely disrupted during construction, and central-area traffic congestion is thereby greatly increased. The designers are, however, sensitive to this problem, and so only a few, short segments of the tunnels are under construction at a given time. The size of the construction area is thus minimized and, where possible, temporary beams and cover plates are used to maintain street capacity at the construction sites.

Because of the use of existing street rights-of-way, of course, no problems associated with the relocation of homes and businesses are expected. Some care has been taken to protect valued historical and cultural features of Seoul from damage from the subway. Special studies were made of potential vibration impacts on East Gate and South Gate, both of which are in the route of the line under construction. As a result, some minor changes in alignment were implemented. No special consideration of subway noise problems seems to have been made. Traditional rock ballast, wood ties, and standard-gauge steel rails will be used. Polyethelene track pads will be placed on the ties, but their contribution to noise reduction is unclear. Tunnels will be smooth concrete, which will concentrate train noise, particularly in the short-radius curves which are planned at several points on the system.

As is typical of the technology, the Seoul subways will provide fast, high-capacity service. Design speed of the system will be 110 kph, although frequent station spacing will reduce average running speeds to around 30 kph (11). This is probably on the order of 2-3 times faster than street traffic. Trains will run on 2.5 minute headways during the peak periods; 10-car trains will have a maximum capacity of about 3500 persons, resulting in a single-track, one-direction capacity of about 84,000 persons per hour. This is almost an order of magnitude greater than current peak-period volumes in the central area. Of course, these figures reflect ultimate design capacity, and in the near future costs can be reduced somewhat by offering less service. At first, six-car trains will operate on 7½-minute headways. Yet the growth potential exists in this mode of travel. After the first line is opened in 1974, it is expected

to carry about 560,000 persons per day, according to the demand estimates prepared by KIST (12). This represents about 10 or 12% of the total CBD-oriented trips in Seoul. This fraction is small because in that year only one line will have been completed; it should increase in the future, but may never exceed 20% of CBD trips. This is because the subway will provide most of its service for longer trips, since station spacing will be greater than surface bus-stop spacing. Representatives of KIST suggested that the subway will only carry the increases in traffic demand during the next few decades. That is, street traffic congestion will stay constant, while subway volumes will go up.

It would be difficult, at best, to arrive at reliable estimates of the long-term effect of the subway on travel patterns and traffic congestion in Seoul. This depends on a number of factors, including the relative levels of fares, travel times, and passenger comfort which the subway offers compared with competing modes in the rapid transit corridors. Since those modes are primarily surface bus, taxi, and private auto, it is likely that the subway will offer superior service for a considerable period of time. As the new facility becomes congested, levels of service of competing modes can be expected to equilibrate, and market shares are likely to be in proportion to system capacities. Of course, even in its own corridors, the subway will not effectively serve shorter trips because of its station spacing, and the bus will carry most of these. As the origin or destination of a traveler gets further from a subway stop, making walking access less attractive, the subway may be rejected in favor of the bus if the latter provides more direct access.

In non-subway corridors, of course, the new system will not divert much traffic. Yet the subway network, as it is ultimately planned, pro-

vides rather good coverage of the major corridors of development radiating from central Seoul. The subway will not effectively serve much of the demand for circumferential movement, except by bringing trip makers into the central area and back out again. And there are significant high-density "wedges" around central Seoul through which the subway does not pass, and which will surely continue to rely on bus service.

The decision to construct such an extensive subway network, however, can only be viewed as a bold action, particularly considering the timing in the development cycles of Seoul and the Republic of Korea. Auto ownership rates are still very low, and bus service seems relatively good. The population of Seoul does not seem to hold strongly negative perceptions of public transit —or at least they have no alternative service. It is evident that trends in the economy and the society will lead to increases in auto availability, although these cannot be rapid. The introduction of high-speed transit at this time will surely have a detrimental effect on the financial statements of many private bus operators. But its most important, long-range contribution may be to divert the course of Seoul away from western-style auto orientation. This should have a beneficial effect on the quality of the urban environment, including air pollution, aesthetics, noise, and traffic accidents. Had the decision to build rapid transit been deferred for a decade, it might have been difficult or impossible to make, and its effective competition with private transportation might not have been so great. It is clear from recent studies of travel behavior that habit and experience are major influencing factors (13). High quality rapid transit may help develop these habits.

A more thorough economic analysis would probably show that, in terms of utilization of national resources for urban transportation, the subway is superior to an auto-oriented system. In addition, construction of the subway now makes an important contribution towards increasing employment in Seoul, an issue which has had an influence on the choice of construction technology.

Finally, it must be pointed out that the subway is perhaps the most rigid of the available urban transport technologies, adapting rather poorly to changes in land-use patterns and life styles. This should be obvious because of its fixed nature: tunnels, tracks, and stations are essentially immoveable, especially when compared to auto and bus facilities and routes. Thus, the subway will tend to lock Seoul into its current pattern of spatial development, with a strong, commercially-oriented downtown, and radial residential corridors. It is evident from a simple comparison of population density and subway maps that the system was designed to respond to current and expected development patterns. The subway planners worked closely with the Seoul City Planning Bureau in developing the network design. As stated earlier, what is not clear is the validity of the foundation of the antecedent urban development plan. There may be significant social, environmental, and economic problems associated with reinforcement of this central focus of the city. On the other hand, there are clear advantages in each of these dimensions as well, and in terms of transportation alone, fewer resources would be needed to service a centrally focused, "classic" form city than some more dispersed alternative pattern. Linkages between transportation and urban development will be discussed later in more detail.

Environmental Impacts of Transportation in Seoul

It is difficult to assess with accuracy the environmental impacts, existing and potential, of urban transportation in Seoul. In part, this is because the state-of-the-art of transportation impact assessment is quite limited. It is also because there is so little concern for these potential problems in Seoul. As a result, very little relevant data were found, and few professionals concerned with urban transportation had a serious interest in environmental impacts. This is quite reasonable, particularly viewed from the perspective of recent U.S. experience. The current state of economic development in Seoul, and the pressures of a rapidly increasing population, result in a system of priorities focusing on immediate necessities. In the transportation sector, this means immediate concern for providing essential accessibility, sufficient capacity, and reasonable levels of service. Limitations in available resources —especially skilled human resources —necessitate planning under objectives based primarily on transportation service, and much less on environmental impacts.

It is easy to argue that increased concern for environmental impacts s long overdue. Yet only in recent years has this concern developed in the nited States, where urban transportation systems have been highly developed or many years. Therefore, one must evaluate the relative emphasis on environmental planning and impacts in Seoul in the context of local needs and esources. In this light, the people of Korea are making good progress, for, s stated earlier, one cannot fairly evaluate environmental impacts of technological systems unless one has good information on the needs for, and enefits of, those systems.

Perspectives on some of the primary environmental impacts of urban transportation in Seoul are presented below.

Air Quality: The city of Seoul consists of very densely developed districts in valleys surrounded by, and interspersed with, mountains. Thus, pollution loads in the atmosphere tend to collect over the city. As is typical of Korea —Chosun, the land of the morning calm —prevailing winds do not contribute much to the dispersion of pollutants. The high density of development aggravates the problem of pollution due to space heating. Furthermore, both density patterns and the focus of trips on the central business district tend to increase localized pollutant concentrations in the center of the city. The circuity of the road network increases trip lengths, and thus increases pollution emissions from motor vehicles. In addition, downtown street congestion makes this problem worse, for vehicles spend more time making given trips, stand idling in one place for long time periods, and move at low travel speeds.

On the other hand, since 80% of the trips are by buses, many of which are diesel powered, total pollutant load is much less than would be expected in an automobile-oriented city of equivalent size. Furthermore, because so few people commute into and out of the central business district by private car, the evening peak period "cold start" problem is eliminated. That is, during the cold start and warmup period, gasoline-powered internal combusion engines make their most noxious contributions to air pollution; but auto availability and travel patterns in Seoul make this phenomenon unimportant at the present time.

No specific data on ambient air quality in Seoul were gathered for this study. In part, this is because the city of Seoul was just beginning

to monitor air quality on a regular basis during this investigation. More importantly, however, it was clear that no valid information was available regarding the motor vehicle contribution to air pollution. Thus, since it was impossible to attribute any specific fraction of the responsibility for air pollution to vehicular traffic, the search for more specific data was abandoned. Staff members at the Ministry of Transport judged that about 30% of the pollution load was due to vehicular emissions, but they had no opinion regarding the nature of these emissions. It is most likely that the overwhelming proportion of atmospheric pollutants in Seoul is space heating with anthracite coal. At street level in the downtown, however, the impact of vehicles is surely more serious.

A variety of public policy options are being exercised or considered which will influence future vehicular pollution. The Ministry of Transport, for example, operates a vehicle-inspection program throughout Korea. Ten inspection stations are privately operated in Seoul under this program. While the primary concern of the inspection is safety (visual system inspection, headlight test, axle loading check, brake test, and speedometer check), pollution emissions are also analysed. The latter are limited to analysis of the volume percentage of carbon monoxide and particulate emissions. The CO test is performed using a small gas chromatograph and a probe inserted in the exhaust pipe. Particulates are verified using a printed Ringleman chart. Vehicles assembled in Korea are inspected on the assembly lines and at the time of registration, since vehicles may be stored for several months prior to sale. Subsequently, vehicles are inspected semi-annually. The standard for CO emissions is no more than 5.5% by volume for a used car; particulate production is limited to a level of 2

on the Ringleman chart. Vehicles not meeting these standards must be repaired before their registration is extended. It is relevant to point out that U.S. pollution emission standards were recently changed to be specified in terms of grams per mile of travel over a representative driving cycle, an approach which provides a better indication of the pollution contribution of vehicles moving around an urban area. Thus, the real value of the current Korean standard, which is based on vehicle performance with the engine idling, is limited and difficult to relate to current U.S. standards.

The quality and extent of this inspection program is quite impressive, considering the many competing uses for resources in Korea. In a sense it is an enigma, for while vehicles are inspected twice each year, no data base seems to exist on ambient air quality. Thus, it would be difficult to judge the impact of this program on air pollution. Yet the fact that an inspection program exists is most encouraging, for its potential role in the control of ambient air quality is very great.

Both the national government and the Seoul city government expressed active interest in emission control devices. These include fuel mixture controls, ignition spark controls, mechanical particulate extractors, and rechargeable exhaust gas converters. Devices have been submitted for evaluation by Japanese and Korean developers, who are financing studies performed by KIST. The results of these studies may lead to legal requirements for control devices on vehicles, although the chain of command in this decision-making process is not clear. The focus of these tests seems to be upon carbon monoxide and particulate emissions. No special concern was evidenced for emissions of NO_x, hydrocarbons, or free lead (Korean gasoline includes a lead additive) in the Ministry of Transport. It was suggested

that the Ministry of Health and Social Affairs was responsible for problems with lead; in any case, M.O.T. had no ability to measure lead, and so could not reasonably be concerned with it. It should be noted that the United States has set no emission standards on lead or particulates, in part because of the difficulty of measuring their concentration.

The concern of the City of Seoul for improving street traffic operations —reducing congestion —is likely to have a favorable impact on vehicular pollution. The special traffic analysis team formed by the city government is responsible for operational improvements and expressway system planning, with the former area having first priority. Improvement of traffic signal phasing, rationalization of traffic flow patterns, and the introduction of through-lane over- and under-passes all will contribute to smoother traffic flows and lower emission volumes. Vehicular pollution, however, is not the motivation for these efforts, and serious consideration has not been given to the cost-effectiveness of this program in terms of pollution reduction.

The fragmented system of elevated expressways also reduces vehicular pollution by smoothing traffic flow and separating longer from shorter trips. Because an integrated expressway system does not yet exist, these facilities do not yet carry a significant proportion of traffic flows, and so their impact on air quality is necessarily small at the present time. When the Seoul traffic analysis team is able to develop and implement an expressway system plan, improvement in the quality of traffic flows will become more meaningful. At the same time, of course, a more extensive expressway system will tend to facilitate vehicular flows in and out of the central area of the city. If experiences in other cities are indicative of potential impacts in Seoul, the net result may be an attraction of more

trips to the downtown, and an increase in air pollution emissions. These relationships are quite complex, and considerable study would be necessary to anticipate the ultimate effect on ambient air quality. Such studies do not seem to be contemplated at this time. It must be recognized that opportunities exist for trading-off emphasis on the central business district of Seoul through traffic flow and accessibility improvements, with its apparent economic, cultural, and social benefits to this developing city, and concern for air quality, with its apparent health and environmental benefits. At the present time, the City of Seoul is clearly orienting its efforts towards the former objective. What is not clear is the degree to which this choice is being made consciously.

The development of the subway system is also a public policy action which could have a favorable effect on air quality, although the magnitude of this effect over time has not been considered in detail. Again, the purpose of the subway program is the provision of accessibility, not the preservation of environment.

Institutional structures which would permit an integrated approach to both transportation and air pollution problems have not yet evolved in Seoul. A number of interacting factors contribute to this situation, and must be dealt with to change it. As discussed earlier, resource allocation priorities now focus on the needs for transportation, and not its impacts. Furthermore, Korea is not now well endowed with the human resources necessary to mount a strong attack on vehicular air pollution. This investigation focused on the transportation sector, and not on environmentally-trained manpower. Yet the absence of environmentally-aware professionals in the transportation field itself will serve as an impedance to the develop-

ment of programs to control vehicular emissions, for without such individuals directly involved in transport planning, pollution control will necessarily be an ad hoc —and potentially ineffective —process. This problem is compounded by the lack of a cadre of strong professionals in the transportation planning field itself. The result of these manpower limitations, in the context of growing transportation needs, could very well be a strong emphasis on the acquisition of only transportation skills, without the associated, and necessary, impact-oriented personnel.

Because of the variety of direct and more subtle linkages which exist between transportation, urban development, and air quality, effective environmental control in this dimension may require the development of an integrated government policy on air quality, with clear lines of responsibility for the implementation of such a policy. The fragmentation of transport-environment responsibilities in both the national and Seoul city governments will make it difficult to plan transportation to meet environmental goals as well as travel needs. Opportunities must be built into the planning and design cycles for enlightened intervention to protect the future quality of the environment in Seoul. This may require administrative changes as well as trained manpower. Finally, effective intervention on behalf of the environment will require a measurement and monitoring capability to provide a data base on air quality for comparative purposes. The focus of measurement and monitoring programs should include the broadest possible set of environmental contaminants.

Noise Levels: Noise from street traffic in Seoul is the environmental impact of transportation most ovbious to the visitor. At the low travel speeds associated with urban traffic, the major source of noise from automobiles, buses, and trucks, is the engine and drive-train system. In Seoul,

however, these noise emissions are usually out-shouted by the sound of auto horns. As described previously, the horn is the major weapon used by drivers in Seoul —and it is used constantly and indiscriminately. The auto horn is often used in response to the heavy congestion in the central area; yet there is reason to believe that this particular kind of street noise can better be understood in social and cultural terms.

The motor vehicle is still new to Korea. Apparently the major growth in the number of vehicles in the country has occurred since the Korean War. Most Koreans are unfamiliar with the workings, operation, and dangers of motor vehicles; this is exemplified by the nature of driver training programs described previously. Furthermore, the very high cost of automobiles, and the rarity of driver's licenses, make the licensed driver or vehicle owner rather unique in status. Among the results of these factors is the tendency to assume the supremacy of the motor vehicle over pedestrians, bicycles, and animal-drawn vehicles. Drivers do not seem to be willing to yield the right-of-way to non-motorized traffic, and they seem to be almost equally impatient with their fellow drivers. The horn and the accelerator are the major offensive tools in the traffic battle; the brake is used much less frequently. In addition, non-drivers do not seem to have an appropriate level of fear of collisions with motor vehicles. Pedestrians rarely look for traffic when they enter a roadway. Newspapers carry many reports of pedestrian accidents, and U.S. military personnel are constantly warned of the pedestrian hazards in Korea. The most significant result of these factors, of course, is the dangerously high accident rates, which will be discussed in the next section of this report. Somewhat less threatening, but more obvious, is the resulting ambient noise level in the streets.

Noise from traffic on elevated expressways may also be troublesome in the future, but relatively low traffic volumes on expressway fragments limits the severity of this problem at the present time.

As in the case of air pollution, no data base on ambient traffic noise levels in Seoul was discovered, and in fact, no particular concern for this potential problem was voiced by the officials contacted. It would seem reasonable to link noise measurement to the new air pollution monitoring program in Seoul; yet, as in the case of air pollution, convenient and effective measurement devices for noise monitoring have only recently become available. Furthermore, concern for noise levels does not have high priority in Seoul, and in part, this may be due to the tendency to interpret high noise levels as a sign of technological and economic progress. It is important, however, that early consideration be given to the potential health hazards of high ambient noise levels, including physiological (hearing loss) and psychological (speech and sleep interference) effects.

The national government's vehicle inspection program does specifically include noise level tests, not for engine and exhaust noise, as in the U.S., but for horn noise. For example, auto horns can produce no more than 115 phons measured one meter above the pavement at a distance of 4-5 meters from the vehicle. The relevance of this inspection standard is weakened by the fact that there is essentially no control of horn usage on the streets. It is said that there are ordinances prohibiting profligate use of the horn, but these are unenforced, and probably unenforceable.

As mentioned previously, concern for noise levels in the new subway is not great; experience in U.S. cities suggests that subway noise can be an offensive, painful, and hazardous characteristic of this transport

technology. Here again, early concern is merited, for efforts to "fix" a system which has already been built have not been found to be cost effective.

Controlling the noise impacts of transportation —like the air quality impacts —requires a reliable data base, on both noise levels and their effects, professional expertise within the transport sector and outside of it, and appropriate priorities for resource allocation in planning, design, and law enforcement. In Seoul, there may also be significant gains to be made through educational programs designed both to warn of the hazards of noise, and to accelerate the process of technological acculturation which might decrease the supremacy of, and increase respect for, the motor vehicle. Finally, control of noise impacts requires the introduction of appropriate intervention opportunities in the public systems decision-making process.

Transportation Safety: Traffic accidents can be viewed as environmental impacts of transportation because, like air pollution, they threaten life, limb, and property, and because they arise as a natural concomitant of the technology and operating policies which are used to provide for the movement of people and goods. Statistics on traffic accidents are relatively good compared to the data available on noise and air pollution. Yet the validity of accident statistics even in more developed countries is often questionable due to inaccuracies in reporting (e.g., problems in fixing locations, types, and causes of accidents), and to problems of insuring full coverage of all accidents. Furthermore, where statistics are reported as rates per unit of exposure (e.g., per 100 million vehicle miles), the accuracy of the rate itself is controlled by the accuracy of estimation of the total exposure. Recognizing these characteristic problems, accident statistics from Korea can only be given a general interpretation.

As shown in the accompanying table, there are about 10 accidents per million vehicle miles of travel in the city of Seoul; for comparison, this rate is only 3.5 on the limited-access inter-city toll roads; there are about 9 injuries per million vehicle miles in Seoul, and 9.34 deaths (14). Both the injury and death rates are excessively high compared to more highly developed countries: the urban area death rate has been estimated to fall in the range of 4 to 12 times that of the United States. There were about 600 traffic accident deaths in Seoul in 1971, or about 0.109 per thousand residents (15). The U.S. national per capita rate is about 0.25 per thousand, yet because of the large number of vehicles on the roads, the rate per unit of exposure in the U.S. is much lower than in Seoul. It is estimated that as many as 98% of the deaths in Seoul arise from vehicular-pedestrian accident. Statistics reported in the Journal of the Korean Medical Association show that, in 1967, accidents of all types were the primary cause of reported deaths (16). What fraction of total accidents is composed of motor vehicle accidents is unknown, but it is likely to be quite high.

Among the causes of the apparently high risk of motor vehicle injury and death in Korea is the very congested nature of downtown streets, which increases conflicts between vehicles, and between vehicles and pedestrians. Even with the extensive system of pedestrian over- and under-passes in Seoul, there are many places in the city where the pedestrian must compete for the right of way with automobiles. These conflict situation, coupled with the attitude of auto supremacy on the part of the driver, and the lack of technological acculturation on the part of the pedestrian, create a very high risk environment on the city streets.

Traffic Accident Statistics — Seoul and Connecting Roadways

(1971 data as published or described by public officials in March, 1972; some figures estimated based on other available data)

	Seoul City	Intercity Tollroads	U.S.A.*
Accidents per 10^6 vehicle-miles	10.0	3.5	15.0 (National)
Injuries per 10^6 vehicle-miles	8.55	2.7	2.0 (National)
Deaths per 10^6 vehicle-miles	0.34	0.25	0.02 - 0.06 (Urban areas)
Total accidents	16,800	1,345	
Total injuries	14,300	1,037	
Total deaths	600	97	

*U.S. Data for 1963-65, from various published sources

To understand the apparent willingness of the residents of Seoul to accept this situation, one must consider the relative value placed on a human life in that city. Such a detailed investigation is beyond the scope of this report, but there are some obvious signs of the differences between Korean and western values:

-on major construction projects, hard hats and other safety equipment is rare; heavy equipment and laborers work side by side, with little or no safety supervision; on the other hand, signs warning the workers about protection of the materials and equipment are common;

-it is said that only 47% of the deaths in Seoul are reported by physicians who might be able to give a reasonable estimate of the cause;

-as stated, drivers have little regard for pedestrians, and likewise, pedestrians pay little heed to drivers;

-Korean parents interviewed did not feel that the primary schools taught children to avoid accidents and to be careful in traffic.

Pedestrian accidents were reported in official documents to account for only 18% of all accidents in Seoul; yet some officials felt that this figure was excessively low.

Generally, the public concern for traffic safety does not seem proportionately high considering the accident rates. Furthermore, while the accident data base is good compared to available data on other transportation impacts, published accident statistics, including causes determined by thorough investigation, location, time of day, type of accident, and extent of injuries are either not available or not reliable. The primary source of accident data is police records which, we have found in other countries, are not necessarily reliable. For example, many accidents may not be investigated by the police. Furthermore, the policeman has many other responsibilities, preventing him from performing a comprehensive

investigation. In Seoul, as in the U.S., policemen are often motivated to rapidly assign the blame and issue a traffic citation, which can lead to biases in reporting. As is the case for other impacts associated with transportation, a valid and continuing data base is necessary for the identification of problems, the design of solutions, and the evaluation of their effectiveness.

A number of existing and potential public policies can contribute to improved traffic safety in Seoul. For example, the strategy of pedestrian-vehicular separation through the use of under- and over-passes, and sidewalk delimitation with chains and guard rails, surely have great positive impacts on pedestrian safety. Again, a comprehensive data base would be helpful for evaluating these facilities and for justifying additional measures of this type.

The normally extensive driver training courses also might contribute to traffic safety, although the safety contents of these courses was not determined in this study. Observed driver behavior, however, suggests that traffic safety may deserve more emphasis in driver education. Pedestrian education could also be beneficial, and should be an important integral part of primary school programs. In general, a major improvement in traffic safety in Seoul could probably be achieved through an overall educational effort designed to acquaint the residents with the dangers of vehicular-pedestrian collisions.

The vehicle inspection program is primarily oriented towards the prevention of accidents due to mechanical failures. Its effectiveness cannot be evaluated, however, without valid time-series statistics on accidents and their true causes. Also, law enforcement can and should play an important role in traffic safety in Seoul. Improvement of regulations regarding

speeds, the yielding of rights-of-way, observance of traffic signs and signals, etc., along with strict enforcement, could add an element of order and safety to Seoul which might reduce injuries and deaths.

Traffic operations improvements are also needed for reasons of safety as well as for improving levels of service to drivers; while such improvements are being planned by the city government, the primary motivation is user service, and not accident reduction. For example, there are few warning and regulatory traffic signs on major streets, and those which exist are not easily visible because of their location and competition with advertising signs. At some very wide intersections, drivers must obey a traffic signal which can be as much as 200 yards from the point at which he is to stop his vehicle. The familiar driver knows where to look for these control devices, and often can stop in time. Frequently, vehicles at such intersections continue to proceed for many seconds after the signals have changed, resulting in potentially dangerous conflicts.

Full development of an integrated expressway system will also contribute favorably to traffic safety, for it will further separate vehicles from pedestrians, and it will also separate long and short trips, reducing average traffic densities and allowing drivers to travel safely at speeds appropriate for their trip lengths.

The prospects for necessary institutional evolution to support comprehensive traffic safety programs are good. Some data exists at the present time, several government agencies now have partial, fragmented responsibility for safety, and safety is a natural area of development within the transportation planning and design hierarchy.

Aesthetics: The visual characteristics of transportation facilities and systems in Seoul do not represent a priority area of concern today. This is reasonable, given the current state of development of the city and the competing uses for resources which might otherwise go into aesthetic planning, design, and construction. Some additional concern for aesthetics now, however, may be appropriate for the planning of larger-scale and long-lived facilities. As we have found in the United States, when priorities can be shifted to less tangible needs in future years, it may be difficult, or at least very costly, to improve the aesthetic characteristics of projects such as the elevated expressways. Among the factors to be considered are the scale of such facilities in the context of their micro-environments, design integration of structures with surrounding natural and man-made landscapes, and the careful treatment of spaces beneath structures which are viewed and used by pedestrians. Consideration of facility aesthetics, as for all other environmental impacts, need not be handled on an "all-or-nothing" basis; compromises and trade-offs can be made so that an economically and environmentally balanced design will result.

Relocation of Families, Businesses, and Institutions: While right-of way acquisition for new transportation facilities in most cities often results in major displacements of people and businesses, this does not seem to be a problem in Seoul. Planners have taken advantage of natural corridors formed by some very wide arterial streets, over which elevated expressway segments have been built. A standard facility location policy is to use such locational opportunities rather than to take new land, particularly because of the current housing shortage in Seoul. Likewise, the new subway requires virtually no additional property acquisition within the 10-kilometer ring.

Hopefully, the current avoidance of this kind of transportation disruption can be maintained in the future. Yet continued institutional awareness will be necessary, for, as a complete expressway system is developed, it is likely that preferred routings will not always involve these joint uses of rights-of-way within natural corridors. In many parts of Seoul which may benefit from expressway service, local topography so constrains the amount of developable land available that existing buildings and their occupants may be threatened. In such areas, however, where solid rock exists at or below the surface, tunneled facilities may be a realistic alternative as long as labor costs continue to remain relatively low.

In general, because of the restrictions in available land resources, future opportunities for joint development of transportation facilities along with residential, commercial, and industrial activities on shared rights-of-way should be thoroughly considered. In areas of the city beyond the 10-kilometer ring, policies of advanced acquisition of rights-of-way should be evaluated both to preserve needed land for highways and to control potential future environmental impacts.

The Koreans have considerable respect for buildings and gates which represent significant aspects of their cultural heritage. As mentioned, special consideration was given to the potential impacts of the new subway on the old gates to the city of Seoul. It will be important to maintain this sensitivity in the future so that such historical features can be protected, not only for the residents of Seoul, but also as attractions for tourists.

Micro-Accessibility Characteristics of Transportation Facilities:

The accessibility characteristics of the transportation system in Seoul must be evaluated at the neighborhood scale as well as at the regional level. For example, the current superblock pattern allows residents of interior spaces easy access to the strip commercial services offered on the arterial streets, reducing transportation costs and shortening trip lengths. At the same time, interior access for emergency services —fire, police, and medical care —in the superblocks presents some difficult problems. This is true not only in the residential districts, but also in the downtown area. One result of this is the use of relatively small fire trucks designed to negotiate the smaller streets. It is likely, however, that emergency response times are significantly lengthened because of these land-use and street patterns. Because of its other advantages, it does not seem wise to abandon the superblock pattern for these reasons. Instead, as a part of new development or rehabilitation programs, compromise solutions should be sought out; these might entail the use of some wider, emergency access and fire-break routes through the interior of superblocks.

In some places around Seoul, transportation facilities have been built which serve as local barriers to pedestrian access. For example, along the north bank of the Han River, southwest and south of the central area, the Third and Fourth Riverside Highways provide good access to and from the downtown and the southwest radial corridors. Yet these roadways provide almost no pedestrian access to the river itself, for they are located on the north edge of the river bed, their rights-of-way are generally fenced, and the river banks are protected by steep rock rip-rap. At other

places around Seoul, and in the new city of Kwang Ju, residents were observed using rivers and streams for a variety of purposes, including washing and recreation. At best, isolation of residents from the Han is a safety hazard, for pedestrians seemed to find ways to cross the fences and the highways to go to and from the river. At worst, these barriers impose unnecessary behavioral restrictions on the local residents. Given the ingenuity with which planners have provided for pedestrian access across downtown arterial streets and intercity toll roads, it should not be difficult to maintain easy access to such physical features as the Han and other rivers, through the introduction of minor design modifications.

Environmental Considerations in Transportation Planning: The negative environmental impacts associated with transportation system development in Seoul at this time are not perceived as critical issues. It is a characteristic of most public systems technologies, of course, that a variety of such negative consequences are normally produced as the system is developed and operated. The degree to which these negatives are considered in system planning and decision-making depends not only on the severity of expected impacts, but also on local priorities. As discussed previously, given the current state of development in the Republic of Korea and the city of Seoul, it is reasonable to expect relatively low priorities to be assigned to environmental issues in current decision-making processes. This, indeed, seems to be the case, as indicated by agency structures and responsibilities, data bases and monitoring programs, and available, skilled manpower located in strategic positions.

Yet, the rate of population and economic growth of Seoul, and the current trends in technological development, suggest that this metropolitan

Transportation and Urban Development

A very special linkage between a transportation system and its urban environment is the effect which that system has on urban spatial development. The structure of transportation networks, and the levels of service offered, can encourage certain urban forms and discourage others. The system can make certain economic or social activities viable at some locations and infeasible at others. It is the spatial pattern of activities —land uses —along with the price of travel, which determines the demand for transportation. Thus transportation itself can be used as a mechanism to control urban spatial development; and for these reasons, transportation planning itself should necessarily take place within a land-use planning framework, so that these relationships can be effectively and directly considered. Since patterns of urban development themselves may have significant environmental effects, there exists this larger, macroscopic relationship between transportation and environment.

While the basic spatial framework of the city of Seoul focuses on the strong central business district, decentralization of land uses has been attempted. During the late 1960's, when the city of Kwang Ju was developed, at the time under the sponsorship of the Seoul government, consideration was given to a policy of decentralization through the development of a series of satellite new towns. Kwang Ju is linked indirectly to Seoul via the Seoul-Pusan TollRoad, but there are several miles of poor roads between the new town and the toll road. An older highway connection to Seoul is partially unpaved, and some sections of it are only one lane wide. Perhaps the underlying development strategy involved forcing Kwang Ju to become economically self-sufficient by making commutation to and from Seoul more difficult. Currently, bus service exists between

about desired spatial patterns, while not at the same time encouraging undesired patterns. Despite the fact that many different planning maps show a rather complete network of expressway-type facilities penetrating the hinterlands of Seoul, interviews with public officials suggest that no firm plan yet exists. Thus, it is impossible in this report to evaluate the macro-environmental impacts which Seoul's transportation system may have on its spatial development pattern. It is essential, however, that such linkages be recognized, and that transportation planning and land-use planning be carried out jointly. The responsibility for transportation system planning has recently been assigned to the *ad hoc* transportation analysis team mentioned earlier; this group is advisory to the Second Vice-Mayor of Seoul, who is also responsible for the City Planning Bureau. Even with this close administrative linkage, it is not clear that carefully evaluated spatial plans will serve as the basis for future transportation plans. The city plan is viewed by some professionals as an extremely flexible document; the data base and evaluative processes on which it is built appear to be uncertain. While the competence of the transport planning unit is high, the value of its products may be limited by the information on which they are based. The ultimate result could very well be a transport network designed to meet an existing trends-development trajectory which has not been effectively evaluated.

These impressions are based in part on the tendency for all public programs in Seoul to be evaluated in terms of hard economics. The obvious danger in this approach is that environmental issues of major importance may be easily left aside because they cannot be described in monetary terms. Thus, in the urban planning sector, too, there is a need for environmental awareness and responsibility within the administrative structure of the city of Seoul.

Urban Transportation Planning Strategies in Seoul

To understand the current and potential environmental impacts of urban transportation in Seoul, it is important to understand the processes and techniques of urban transportation planning. It is the planning process which should control the evolution of the city's transportation system, the degree to which it meets the needs of the population, and the nature of its various impacts. Furthermore, if a broad set of environmental impacts is to be considered in the development of the transportation system, it is logical to expect that at least part of the responsibility for this consideration should be built into the transportation planning process. Finally, in many cases it will be necessary to trade off potential environmental impacts against the gains associated with meeting travel demands. The ability of decision makers to effectively consider such trade-offs is directly related to the quality of information with which they are provided —information describing both travel demands and environmental effects.

Responsibility for transportation planning in the Seoul area seems to be rather fragmented. The Bureau of Tourism and Transportation has responsibility for regulating routing and scheduling of buses in Seoul, including both private and municipal services. This bureau also sponsored the 1969 origin-destination survey performed by KIST; it also is concerned with evaluating emission-control devices. The Bureau of City Planning developed and updates the plan; it, in turn, is served indirectly by the traffic analysis team, a staff group reporting directly to the Second Vice-Mayor. The latter seems to be the focal point of expertise in transport planning within the city government. It is an ad hoc unit, established within the

past year, composed of one full-time employee of the city government and three consultants, two from Seoul National University and one from the Korea Institute of Science and Technology. This small group is supported by a few junior staff members of the city. The primary responsibility of the team at the present time is the identification and solution of short-term problems: downtown street capacity, intersection operations, traffic safety, etc. Under the leadership of Professor Imm Sung Pin, a self-trained transportation specialist from the Civil Engineering Department of Seoul National University, this small group has undertaken some impressive and ambitious projects. The team also has the responsibility to plan the expressway system for the metropolitan area, a task which it expects to undertake in the near future. While the data base from the 1969 study will provide essential support for this effort, the transportation analysis team does not yet seem to have the financial, manpower, and data resources which may be necessary to undertake such a large task. Furthermore, it is ambitious to expect a single administrative unit, with a small, part-time staff, to be able to effectively handle both long-range and short-range planning. It is likely that this massive responsibility has been allocated to Prof. Imm and his colleagues because they represent a majority of the professionals trained in the skills needed for urban transportation planning in Korea. The lines of authority through which information flows to and from this group are uncertain at best.

The Seoul subway project is being managed by an agency which is also a division of the city government. Its connection to the traffic analysis team --which technically should be quite strong --does not seem to be particularly clear. Its major relationships seem to be with the City Planning Bureau. Yet, expressway planning and rapid transit planning should

realistically proceed in a simultaneous, integrated fashion.

The Ministry of Construction of the national government must approve the location of major facilities (wider than 12 meters) in the city of Seoul. The role that MOC plays in planning and decision-making processes is not clear, but it is said to hold primarily a review function. MOC is responsible for planing and design of intercity roadways; operation of toll facilities is then turned over to the Korean Highway Corporation. The national government pays all costs of the intercity roadways, as well as costs of connecting facilities within one kilometer of them. Beyond one kilometer, the MOC pays only 50% of the costs of connections to urban areas.

While the hierarchy which holds the responsibility for urban transportation planning in Seoul is still evolving, there are some obvious problems which may reduce its ability to perform comprehensive planning, analysis, and impact evaluation. As mentioned, the responsibilities for tasks which are clearly inter-related are shared by numerous agencies, and lines of authority and communication seem to be poorly defined. As a result, critical issues might easily fall between the cracks. This is particularly true in the case of environmental impact sensitivity: competing, modally-oriented or jurisdictionally-based institutions may not recognize the need to consider the negative aspects of proposed projects, being too caught up in the pressure to build new facilities. Significant environmental awareness does not seem to exist in any of the transport-related agencies. A solution to this problem may be the creation of an environmental watch-dog agency; yet this cannot be effective unless an impact analysis capability is built into transport agencies themselves. This is because the fundamental issues will be in the area of the trade-offs between providing

transport services and reducing negative impacts. Both sides of these decisions should logically be considered in the same context and at the same level of analysis.

A primary example of the effect on agency structure of lack of emphasis on long-term environmental impacts may be the absence of studies of the impact on the spatial development of urban structure in Seoul brought about by the transportation system. The system itself, at least in the highway sector, has not been thoroughly planned; yet, small components of it are being built as solutions to short-term, operational problems. The ability of the City Planning Bureau to perform this kind of long-range evaluation is limited. As a result, it is possible that environmentally and socially detrimental decisions are being taken on a daily basis, the consequences of which may remain unanticipated, and may also be difficult or impossible to reverse in the future.

The traffic analysis team, as stated, is a center of excellence in this whole process. Yet its members do not yet have the skills to consider long-range, environmental effects; furthermore, the pressures they experience to solve short-term problems, with extremely limited resources, will restrict the ability of this group to grow to meet the challenges of the future. The ad hoc nature of this group --the fact that its real strength is in its part-time consultants --is another factor which cannot be viewed positively. While the opportunity to participate in this task is of clear value to the participants from SNU and KIST, especially from an educational point of view --they are being exposed to practical problems which will benefit their future research and teaching --the apparent opportunities to use the problems of Seoul as a mechanism for more direct investments in the future manpower pool in Korea are being lost. For example,

if the ad hoc nature of this group continues, it seems reasonable to suggest that the city, and the national government, should seriously consider strategies for more directly strengthening the programs at SNU and KIST. Resources are not flowing directly to these institutions, but to their individual representatives instead. The benefits to students and to other research contractors are indirect at best. The university, in particular, does not have the resources to effectively carry this new knowledge to graduate and undergraduate programs. The result may be viewed as short-term consumption of scarce human resources without efforts to replace them.

Perhaps the most apparently weak link in the overall planning process is at the level of macroscopic policy evaluation and choice. The current fragmentation in organizational structure seems to leave out the clear responsibility for overall systems integration: planning an integrated, multimodal transportation system for the Seoul region, and fitting that transportation system into the design of the urban spatial system, including consideration of long-term social, economic, and environmental impacts. One role this policy evaluation capability could and should play is the careful analysis of major developmental alternatives for Seoul: satellite cities plans, sub-civic center plans, CBD-focus plans, dispersed development plans, etc. Each of these more general options should be evaluated in terms of the associated programmatic responses necessary to make them work (transportation, water supply, waste water treatment, education, industrial development, etc.), and in terms of the spectrum of costs and benefits which result, in turn, from these supportive programs.

Within the context of this policy evaluation process, some emphasis might be placed upon technological assessment. The Republic of Korea is

rapidly acquiring a variety of technologies which are new to the country. The increased availability of the automobile, and the facilities which are being developed to serve it, provide only one example. One can also view dispersed, lower-density urban development patterns as concepts related to the infusion of the automobile technology. The adoption of this innovation might realistically be viewed as only an option in Korea; alternatives exist, and they merit careful evaluation. This matter should be treated as a specific policy choice, instead of allowing Korea to follow the development trajectories of more developed countries, where an innovation was adopted outside the context of conscious planning and, as a result, a variety of unexpected economic and environmental consequences were brought about. More simply stated, Korea, and the City of Seoul, are faced with real opportunities to make policy choices regarding technological and environmental changes —opportunities which are no longer available to countries which are now highly developed. It may be unwise to make developmental decisions on the basis of what other countries have done, and perhaps have done wrongly. Instead, careful consideration of all of the potential impacts should be utilized to help Korea grow <u>not like</u> Japan or the United States, but <u>better</u> than other countries.

The more detailed characteristics of the transportation planning process must also be considered to assess its ability to meet the needs and evaluate the impacts associated with transport improvements:

<u>Data Base</u> - the results of the 1969 Seoul origin-destination study represent a strong basis for future planning, but this basis must be kept up to date at regular intervals. The most economical approach for accomplishing this may be the process of very small-scale, continuous sampling.

In this way, the entire city might be re-surveyed at five-year intervals. More detailed attitudinal and behavioral studies would also be useful for identifying key factors to be included in future travel-demand models. The quality of the land-use data base, on which future travel estimates will necessarily be built, is questionable. Strengthening this information component should be accomplished in conjunction with improvements in administrative linkages between city planning and transportation planning.

Current environmental-quality data is essential both for predicting impacts of proposed systems and to serve as a baseline for comparison of alternatives. Among the required data which should be maintained on a regular basis are ambient air quality, ambient noise levels, and location- and type-specific accident statistics.

Data on the characteristics of current transportation services, especially travel, transfer, and waiting times should be collected. Travel-time characteristics have been found to be the primary determinant of travel behavior choices in western countries. Despite the low per-capita income in Korea, it is apparent from the pace of pedestrian and vehicular traffic in Seoul that time is highly valued. Currently, those travel forecasts which are developed using mathematical models in Korea assume that distance is the primary choice variable, and this assumption is made because travel-time characteristics are not available. The results are very likely significant biases associated with travel demand estimates, particularly those for new, faster facilities. More specifically, distance-based forecasts are likely to result in underestimates of demand, under-design of facilities, and congestion.

Finally, efforts should begin at once to continuously monitor social and economic responses to changes in the transportation system through the use of carefully constructed before-and-after studies. These should focus on changes in trip-making characteristics, mode choice, route choice, residential location shifts, employment location shifts, and changes in shopping and recreation patterns. Through theses studies the ability to anticipate the precise impacts of future transportation system changes will be improved. Otherwise, it will be necessary to estimate potential impacts on the basis of models calibrated in other cities, which is likely to lead to erroneous estimates and to the possibility of "borrowing" developmental paths from those other cities.

Forecasting Capabilities - The city of Seoul seems to be somewhat behind the international state-of-the-art in travel demand forecasting, which is not unreasonable compared to some cities in more developed countries. For example, the use of distance-based forecasts has generally been abandoned because it can lead to troublesome results, as described above. There are several reasons for this gap. First, as stated, the full set of required data is not yet available. Second, a critical mass of skilled manpower does not yet exist in Korea. Third, even for the most skilled of Korea's transport experts, such as Prof. Imm of Seoul National University, access to the most recent western literature is quite limited. This is a need which could be met at small cost, but it is a critical one. Finally, the monetary resources necessary to remedy the above problems and to conduct the required studies do not seem to be available.

Essentially no activity in the area of environmental impact forecasting was discovered. It should be sufficient to point out that unless potential future environmental effects of public system investments can be estimated with reasonable accuracy, it will be impossible to control the impacts of those systems.

Evaluation strategies - The focus of evaluation strategies used in the transportation sector in Korea is on traditional economic analysis (18). In this approach, monetary estimates of benefits from new systems are weighted against monetary costs. As a result, it becomes very difficult to estimate the worth of reducing environmental impacts. Any effect not readily measured in monetary units tends to be left out of the analysis, to be treated as a free good. The continued use of this approach to systems evaluation will be especially threatening to the living environment of Seoul. Complete reliance on this approach has largely been rejected in the United States and western Europe; instead, economic benefit-cost analyses are used, along with comprehensive descriptions of all significant impacts, often in the form of impact matrices.

It could be argued that, given its current level of economic development, the scarcity of monetary resources supports the strict use of economic analysis for investment planning. This argument tends to be supported by the guidelines offered by international lending institutions. The unfortunate result may be that irreversibly damaging choices are being encouraged today. The absence of an easily established market price for a resource, such as air, water, land, and the human life, does not mean that the resource is without value. Decisions which are truly economically efficient in the broadest sense can only be made with the broadest possible information base.

In-Country Skills Development

The development and utilization of a skilled manpower base in Korea will be an essential element in the avoidance of future transportation-related environmental problems. It is not sufficient to bring in capital and material resources to meet current and future needs. It will be important to develop human resources so that those needs can be met effectively, safely, and economically. Currently, the manpower resources in the fields of transportation planning, environmental protection, and transportation-environment linkages are extremely limited. Furthermore, those skills that exist might be used more effectively.

Two primary sources of these skills are housed at Seoul National University and at the Korea Institute for Science and Technology; these institutions together employ perhaps two well-qualified professionals in the relevant fields and approximately six more in contributory areas. Adequate support for research and teaching on the part of these professionals is not made available. They also do not seem to be effectively utilized in the solution of the current problems of Seoul; given the quality of the human resources at KIST, for example, it seems unrealistic for it to be necessary for this institution to be forced to actively market its services. Cases were also cited where public officials were reluctant to take the advice of in-country professionals on technical matters.

The use of foreign consultants seems quite common in Korea. While this is appropriate where no in-country skills exist, it may be a good investment to insist that such consultants also contribute to the training of indigenous professionals in the course of their work. Reliance on consultants alone is a form of disinvestment in the future of Korea.

The foreign visitor to Seoul is necessarily impressed with the Korea Institute of Science and Technology, its staff, its physical plant, and the quality of its products. Yet the conditions at Seoul National University, including physical plant, size of its staff, and available library and laboratory facilities, are not conducive to the development of an adequate corps of trained Korean professionals. Strategies might be identified for establishing stronger links between KIST and the universities, so that limited manpower resources could be pooled, not only to solve contemporary problems, but also to develop a cadre of professionals who could meet the needs of the future. In association with this approach, additional resources should be allocated to KIST and the universities so that these institutions can accomplish these tasks. New funding could appropriately be linked to the continuous involvement of such institutions in problem solving for the city of Seoul and the government of Korea. Such linkages might include work-study programs to place students in problem-solving roles for government, and in-service training programs for full-time government employees.

In addition to these longer-term approaches to building up in-country skilled manpower, short-term benefits could be achieved by sending selected students, with full funding, for graduate study in such countries as Japan, the United States, Canada, and in western Europe. To insure that such students receive relevant training, and to insure that they are effectively utilized on their return to Korea, commitments should be made to them in advance as to their career opportunities when their education is completed. Very quick returns could also be achieved by sending some Korean professionals and academics, who seem to have made personal commitments to the transportation field, for advanced study in other countries.

Recommendations for Improved Transportation-Environmental Planning in Seoul

The preceding pages summarize an individual perspective on transportation-environmental relationships in Seoul, Republic of Korea, based on a short, two-week study tour. A comprehensive and unbiased analysis of the problems and opportunities which exist cannot be accomplished within such a short time-frame. Thus, the recommendations which were offered in the above sections, and which are summarized below, must necessarily be viewed as tentative points for the initiation of discussion. These recommendations are broadly grouped in three categories: transportation-environmental planning strategies, the evolution of a more responsive planning-decision-making infrastructure, and the development of manpower resources for planning in Korea.

Planning strategies: The concepts of integrated, systems planning should form the basis of transportation system development in Seoul. Comprehensive, multi-system plans should be prepared to serve as guidelines for more specific, sectoral planning. Specifically, the approved, comprehensive master plan should serve as the basis for multi-modal transport planning. The comprehensive plan itself should be evaluted in terms of the economic, social, and environmental impacts of the general plan and of the components which will operationalize that plan --transportation, water supply, waste treatment and disposal, education, health care, housing, employment, recreation, etc. Comprehensive planning should therefore be a continuing, on-line activity, having constant interaction with sectoral planning functions.

Within the transportation sector, continuing priority should be placed on system planning. The urban transportation system for Seoul, including

subways, buses, expressways, and arterial streets, should be planned together to take maximum advantage of positive interactions between these components, and to guard against negative synergisms. At a lower level of analysis, the epxressways should be planned as an integrated system for the same reasons.

In the development of both land-use and transportation system plans, greater sensitivity to potential environmental effects should be developed now. Although logical, short-term priorities in Seoul may seem to mitigate against current concern for the environment in favor of concern for economic factors, many negative environmental consequences of a developing urban transportation system are irreversible, or are reversible only at high costs. At the same time that Seoul and the rest of Korea are leapfrogging many decades of technology, government agencies should attempt to borrow from more highly developed countries the newly developing awareness for protection of the environment. For Korea, now may not be too late.

To operationalize this environmental sensitivity, clearly stated environmental impact criteria should be used to evaluate all major system plans, including those for land use and transportation. Specific consideration should also be given to the early establishment and use of a large-scale, long-range policy evaluation and technology assessment function, designed to carefully and thoroughly evaluate major alternatives for the city of Seoul. This function should be designed to guard against unconscious public choices which could have very long-term detrimental impacts on the society, the economy, and the environment of Seoul. It should have the responsibility of examining proposals issuing from the major planning sectors in each of these general dimensions. In particular, it should

force answers to the questions, "What will happen if this policy is implemented?" and "What will happen if this policy is not implemented?" Clearly, these are tasks which most highly developed countries are just beginning to address, and the techniques for accomplishing them are quite limited. Even rudimentary answers, however, can be of great value in large-scale, long-term decision making.

Efforts should also begin in the near future to create a data base to support system planning and evaluation in the area of transportation-environmental relationshios. This data base should include coverage of travel patterns, transportation system service characteristics, and environmental status --ambient air quality, ambient noise levels, traffic accident characteristics, and micro-environmental effects of transportation. The timeliness of this data base should be maintained through the process of continuous system monitoring. The monitoring process, in addition to providing an updating mechanism, will also provide the support for before-and-after impact studies. The latter will be the foundation upon which an environmental impact forecasting capability can be built.

Infrastructure evolution: One general step toward the achievement of the above goals is the clarification of administrative lines of responsibility so as to bring about accountability for the performance of these tasks. This might be accomplished by creating a strengthened long-range planning agency in the city of Seoul, having responsibility for total urban system development. Within such an organization, all transportation-related functions might be under the aegis of a single unit. These functions should include expressway planning, rapid transit planning, arterial street planning, bus and taxi regulation, as well as system operation. Any re-

organization plan should be based on studies of the administrative successes and failures experienced by other cities around the world. Each unit in such an agency should be well staffed with sufficient full-time employees to effectively carry out the tasks at hand. For the sake of efficiency, administrative structures should be sufficiently flexible to allow the sharing of resources, such as personnel, data, and equipment, especially when one subdivision is faced with differentially large work loads.

The transportation unit, as well as others within the agency, should be specifically charged with the examination of the environmental effects of all projects it considers. Furthermore, an overall environmental assessment responsibility, covering all aspects of the work of the planning agency, should be established within a permanent, administratively protected unit which serves as staff advisor to the agency head. This group should, in conjunction with the functional environmental units, serve as an unbiased watch-dog unit. It should conduct systematic, objective, environmental assessments of all major proposals, insuring that relevant, long-term impacts from all types of projects receive careful and consistent study. While early establishment of such an environmental infrastructure is strongly suggested, it would be reasonable to keep the scale of these activities small for some time --e.g., one staff member in each functional area, and three to five in the overall assessment unit.

Long-term developmental policy evaluation might be handled in the same way, through the creation of a top-level staff group in the planning agency. Environmental assessment could be encompassed within this unit, along with technology assessment, social evaluation, economic analysis, etc.

Human Resources Development: Initiation of long-term investments in skill development should begin immediately. The nucleus of such programs exists now in the Seoul area, and the principal need at the present time is to utilize this nucleus effectively.

A basic step which should be taken is to strengthen university training programs in transportation planning and transportation-environment relationships. The objective should be to produce perhaps 6 to 10 well-trained Master of Science-level graduate students, and one Doctor of Philosophy, each year. It will be important not to flood the market with such professionals, but at the same time, it is clear that a trained cadre is vitally needed. To accomplish this objective, it will be necessary to invest additional public resources in the universities. These investments could be tied directly to university involvement in urban transportation problem-solving for Seoul. The latter approach would not only result in early benefits to the city, but would also provide a more relevant basis for training of graduate students. This type of relationships is only now being proposed by the Department of Transportation in the United States.

Methods should also be sought to better utilize the impressive strengths of the Korea Institute of Science and Technology in the training of students. Hopefully, this can be accomplished without diluting the autonomy of either KIST or the universities.

In the short run, serious consideration should be given to the training of transportation-environmental specialists outside of Korea to provide the in-country skills necessary to strengthen a Korea-based educational program.

Guidelines for USAID in Seoul

To assist the Korean people, and people in other rapidly urbanizing nations, in the achievement of the objectives stated in the previous sections of this report, it will be important for USAID itself to be concerned about long-term social and environmental impacts of public works investments. This calls for increased emphasis on planning, evaluation, and decision processes, along with the provision of resources for public works investments themselves.

Specific concern should be established within USAID programs for the development of on-going, broadly based systems-planning processes in the Seoul area. Development of data bases, continuous monitoring programs, modern impact forecasting techniques, and comprehensive evaluation strategies should be strongly encouraged. These ends may be accomplished through at least three alternative approaches: direct funding of planning process innovations in Korea, linkage of planning strategies changes to AID-supported physical development projects, and the provision of advisory services outside of specific public works projects.

Improvement of system planning methods may be encouraged through the use of appropriate criteria for some future AID funding. For example, indications of progress towards the development of macroscopic policy evaluation capabilities, integrated systems planning, environmental impact analysis evaluation, and data-base evolution might be offered as pre-stated milestones on which to base future project support decisions.

Generally, AID capital investment programs in the transport field, and in other sectors, should include specific provisions for continuous system monitoring, so that data bases and the foundations for future impact forecasting can be established.

The rate of development of the urban transportation system in Seoul seems to be satisfactory at the present time with no apparent AID support. Still, it may be appropriate to use a limited amount of AID funds for improving the planning process itself. As stated, good use of these resources could be made in activities such as the establishment of a high-level policy-evaluation/environmental-assessment unit, the creation of a formal transport-system planning agency in Seoul, and the institution of comprehensive environmental-quality monitoring programs. Funds could provide for limited-term personnel salaries, training for in-country professionals, facilities and equipment. The future of such an agency would be promising to the extent that it is able to develop strong data collection, analysis, evaluation, and reporting techniques.

AID should also develop its own environmental assessment capability within the Mission in Seoul. This might be limited to a single professional, who would be continuously available to provide guidance to the Korean governments regarding anticipation of environmental effects of transportation and other public sector facilities. Experience with such a technical representative should be carefully evaluated to provide a basis for making decisions about expanding this activity to other countries. Eventually, these in-country representatives might be supplemented by traveling teams of more specialized experts who could make periodic visits to deal with specific problems.

A variety of options should be considered for assisting in the development of human resources for transportation-environmental planning in the Seoul area. These include the following:

- Support of the purchase of relevant books and journals for university libraries. This support should include not only money for the purchase of such literature, but also assistance in insuring rapid delivery to Korea. Textbooks ordered through normal, sea-mail channels often spend six to twelve months in the ordering/transit process.

- Promotion of scholarly and professional exchanges between the U.S. and Korea. Selected Koreans might be funded for several months of study and travel in the United States. Programs should be systematically structured so that maximum use of such learning can be made once participants return to Korea. Support should also be provided for U.S. scholars and professionals to visit Korea for the purpose of giving seminars, teaching short in-service training courses, and offering advice to government agencies.

- Support of graduate study in the United States for selected Korean students. This program, too, should be carefully designed so that students acquire a relevant set of skills for working in transportation-environmental planning. Agreements should be reached in advance to insure that such students, upon their return to Korea, will be effectively utilized for both problem-solving and education.

- Small-scale, rapid-response programs should be established by USAID to fund travel by selected Korean transportation-environmental experts to international conferences. A fixed annual budget —perhaps $10,000 —might be established for such a program, and attendees might be selected by the Korean government, based on AID-suggested criteria. These criteria should insure that participants chosen are those who can take maximum technical advantage of such conferences. Rapid response to requests for such support is essential to the success of a program of this nature.

- Technical support of non-USAID projects. Even though USAID may not be financially involved in major transport projects in Seoul, it would seem appropriate to offer limited kinds of technical advice. This should not be in the form of funding planning and design processes through U.S. consultants; instead, it should be limited to strategic advice designed to infuse appropriate systems-planning and evaluation methodologies into Korean decision processes. This might best be accomplished by sending small visiting teams of U.S. experts to Korea for the purpose of studying a single major problem.

- Where a USAID-funded project requires the preparation of an environmental impact statement under the Environmental Policy Act of 1969, such a statement should be prepared jointly by USAID and Korean representatives. Initially, USAID involvement might be relatively high, but these processes should be used specifically as training opportunities for the improvement of the planning capabilities in Korea.

- Serious consideration should be given to direct grants to public universities, to encourage the development of strong Korean graduate programs treating environmental impact assessment in transportation and other sectors. These programs should be structured so that the Korean Government agrees to underwrite their long-term support. Resources should be made available for faculty, visiting U.S. scholars, library development, research equipment, and graduate student stipends. Success of these efforts should be carefully monitored to support decision-making regarding parallel programs in other countries.

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